WHAT IS CLAIMED IS:

1. Interferometric apparatus comprising:

a first beam-splitting surface positioned to separate an input beam into a first beam and a second beam; and

a first set of optics positioned to receive the first beam, direct it to contact a first reflector multiple times and produce a first intermediate beam, the first intermediate beam following a nominal output path when the first reflector has a first alignment normal to the first beam prior to reflection by the first reflector;

wherein the first set of optics comprises a second beam-splitting surface, a third beam-splitting surface, and a first fold optic positioned to reduce displacement of the first intermediate beam from the nominal output path when the first reflector has an alignment different from the first alignment.

2. The interferometric apparatus of claim 1, wherein the first beam-splitting surface is further positioned to combine the first intermediate beam with a second intermediate beam derived from the second beam to produce an overlapping pair of output beams.

3. The interferometric apparatus of claim 1, further comprising a second beam-splitting surface positioned to combine the first intermediate beam with a second intermediate beam derived from the second beam to produce an overlapping pair of output beams.

4. The interferometric apparatus of claim 1, further comprising a steering wedge positioned to adjust a propagation direction of the first intermediate beam to increase an overlap between the overlapping pair of output beams.

5. The interferometric apparatus of claim 1, further comprising a second set of optics positioned to receive the second beam, direct it to contact a second reflector multiple times and produce a second intermediate beam, the second intermediate beam following the nominal output path when the second reflector has a first alignment normal to the second beam prior to reflection by the second reflector.

6. The interferometric apparatus of claim 5, wherein the second set of optics comprises a fourth beam-splitting surface, a fifth beam-splitting surface, and a second fold optic

positioned to reduce displacement of the second intermediate beam from the nominal output path when the second reflector has an alignment different from the second alignment.

7. The interferometric apparatus of claim 6, wherein the fourth beam-splitting surface is parallel to the second beam-splitting surface, and the fifth beam-splitting surface is parallel to the third beam-splitting surface.

8. The interferometric apparatus of claim 1, wherein the second and third beam-splitting surfaces comprise polarizing beam-splitting surfaces.

9. The interferometric apparatus of claim 1, wherein the first beam-splitting surface comprises a polarizing beam-splitting surface.

10. The interferometric apparatus of claim 1, wherein the first set of optics are positioned to cause the first intermediate beam to follow the nominal output path when the first reflecting element has a second alignment different from the first alignment.

11. The interferometric apparatus of claim 1, wherein the second and third beam-splitting surfaces are perpendicular to each other.

12. The interferometric apparatus of claim 11, wherein the first fold optic comprises a first reflecting surface and a second reflecting surface that are perpendicular to each other.

13. The interferometric apparatus of claim 12, wherein the second and third beam-splitting surfaces intersect at a first line, the first and second reflecting surfaces intersect at a second line, the first line being perpendicular to the second line.

14. The interferometric apparatus of claim 1, wherein the second and third beam-splitting surfaces and reflecting surfaces of the first fold optic are positioned so that when the first beam contacts any of the surfaces, the first beam has a polarization direction parallel to the surface.

15. The interferometric apparatus of claim 1, wherein when the first reflector has the first alignment and the first beam is reflected by a surface in the first set of optics, the incident angle of the first beam relative to the surface is substantially equal to 45°.

16. Apparatus comprising:

a beam separating device to separate an input beam into a first beam and a second beam; and

a first set of optics to receive the first beam and to direct the first beam along multiple passes that pass through a portion of the first set of optics, in each pass the first beam propagates towards the first reflector and is reflected by the first reflector, the first set of optics including a first beam-splitting surface and a second beam-splitting surface,

the multiple passes including a first set of passes and a second set of passes, the first reflector having a first alignment that is normal to the propagation direction of the first beam prior to reflection by the first reflector,

the first beam following a first nominal beam path when the first reflector has the first alignment,

the path of the first beam being sheared relative to the first nominal beam path during the first set of passes and during the second set of passes if the first reflector has an alignment other than the first alignment,

the first set of optics including a first fold optic to redirect the first beam after the first set of passes and before the second set of passes so that shear imparted during the second set of passes reduces or cancels shear imparted during the first set of passes.

17. The apparatus of claim 16, wherein the first and second beam-splitting surfaces reflect the first beam between the first and second passes and between the third and fourth passes

18. The apparatus of claim 16, further comprising a second set of optics to receive the second beam and direct the second beam along multiple passes through a portion of the second set of optics, the second set of optics including a third beam-splitting surface and a fourth beam-splitting surface,

the multiple passes through the second set of optics including a third set of passes and a fourth set of passes,

the second reflector having a second alignment that is normal to the propagation direction of a portion of the second beam that is reflected by the second reflector,

the path of the second beam being sheared during the third set of passes and during the fourth set of passes through the second set of optics if the second reflector has an alignment other than the second alignment,

the second set of optics including a second fold optic to redirect the second beam after the third set of passes and before the fourth set of passes so that shear imparted during the fourth set of passes reduces or cancels shear imparted during the third set of passes.

19. The apparatus of claim 18, further comprising a beam combining device to combine the first beam and the second beam into an overlapping pair of output beams after the first beam completes the first and second set of passes and the second beam completes the third and fourth set of passes.

20. The apparatus of claim 16, wherein during the first set of passes, the first beam passes through the first beam-splitting surface, is reflected in sequence by the first reflector, the first beam-splitting surface, the second beam-splitting surface, and the first reflector, then passes through the second beam-splitting surface.

21. A multiple-pass interferometer comprising:

a first set of optics in cooperation with a measurement mirror to direct a measurement beam along a measurement path that passes through a portion of the first set of optics multiple times to produce a first intermediate beam;

a second set of optics in cooperation with a reference mirror to direct a reference beam along a reference path that passes through a portion of the second set of optics multiple times to produce a second intermediate beam; and

a combining optical element to combine the first and second intermediate beams to form an overlapping pair of output beams, the first and second sets of optics each having at least two reflecting surfaces and at least one beam-splitting surface positioned to reduce relative beam shear between the first and second intermediate beams caused by either the measurement mirror being at an angle relative to a first predefined position and/or the reference mirror being at an angle relative to a second predefined position.

22. The apparatus of claim 21, wherein the beam-splitting surface in each of the first and second sets of optics comprises a polarizing beam-splitting surface.

23. The apparatus of claim 21, wherein the first set of optics comprises a first beam-splitting surface and a second beam-splitting surface.

24. The apparatus of claim 23, wherein the first and second beam-splitting surfaces are perpendicular to each other.

25. The apparatus of claim 23, wherein the second set of optics includes a third beam-splitting surface and a fourth beam-splitting surface, the third beam-splitting surface being parallel to the first beam-splitting surface, and the fourth beam-splitting surface being parallel to the second beam-splitting surface.

26. The apparatus of claim 21, wherein the first set of optics comprises at least one corner cube retroreflector that in cooperation with the beam-splitting surface and the measurement mirror directs the measurement beam along the measurement path.

27. The apparatus of claim 21, wherein the measurement path passes through a portion of the first set of optics in at least a first set of passes and a second set of passes, the at least two reflecting surfaces and at least one beam-splitting surface of the first set of optics are positioned so that shear imparted to the measurement path during the first set of passes is compensated by shear imparted to the measurement path during the second set of passes when the measurement mirror is at an angle relative to the first predefined position.

28. A method comprising:

separating an input beam into a first beam and a second beam; and

directing the first beam through a first set of optics to contact a first reflector multiple times to produce a first intermediate beam, the first intermediate beam following a nominal output path when the first reflector has a first alignment normal to the first beam prior to reflection by the first reflector, the first set of optics comprising a first pair of beam-splitting surfaces and a first fold optic positioned to reduce displacement of the first intermediate beam from the nominal output path when the first reflector has an alignment different from the first alignment.

29. The method of claim 28, further comprising combining the first intermediate beam with a second intermediate beam derived from the second beam to produce an overlapping pair of output beams.

30. The method of claim 28, further comprising directing the second beam through a second set of optics to contact a second reflector multiple times to produce a second intermediate beam, the second intermediate beam following the nominal output path when the second reflector has a first alignment normal to the second beam prior to reflection by the second reflector, the second set of optics comprising a second pair of beam-splitting surfaces and a second fold optic positioned to reduce displacement of the second intermediate beam from the nominal output path when the second reflector has an alignment different from the second alignment.

31. A method comprising:

assembling a first beam-splitting surface, a first set of optics, and a beam-combining surface to form an interferometer;

wherein the first beam-splitting surface during operation of the interferometer separates an input beam into a measurement beam and a reference beam;

wherein the first set of optics comprises a first pair of beam-splitting surfaces and a first fold optic that are positioned to direct the measurement beam to contact a measurement mirror multiple times to form a first intermediate beam, the first intermediate beam following a nominal output path when the measurement mirror has a normal alignment, the first pair of beam-splitting surfaces and the first fold optic positioned to reduce displacement of the first intermediate beam from the nominal output path when the first reflector has an alignment different from the normal alignment; and

wherein the beam-combining surface is positioned to combine the first intermediate beam with a second intermediate beam derived from the reference beam to form an overlapping pair of output beams.

32. The method of claim 31, further comprising assembling a second set optics with the first beam-splitting surface, the first set of optics, and the beam-combining surface to form the interferometer;

wherein the second set of optics comprises a second pair of beam-splitting surfaces and a second fold optic positioned to direct the reference beam to contact a reference mirror multiple times to form the second intermediate beam, the second intermediate beam following a nominal output path when the reference mirror has a normal alignment, the second pair of beam-splitting surfaces and the second fold optic positioned to reduce displacement of the second intermediate beam from the nominal output path when the second reflector has an alignment different from the normal alignment.

33. The method of claim 31, wherein assembling the first beam-splitting surface, the first set of optics, and the beam-combining surface to form the interferometer comprises positioning the first pair of beam-splitting surfaces so that they are perpendicular to each other and intersect at a first line, positioning the first pair of reflecting surfaces so that they are perpendicular to each other and intersect at a second line, the first line being perpendicular to the second line.

34. A method comprising:

separating an input beam into a first beam and a second beam;

directing the first beam along multiple passes that pass through a portion of a first set of optics, in each pass the first beam propagates towards a first reflector and is reflected by the first reflector, the first set of optics including a first beam-splitting surface and a second beam-splitting surface that reflect the first beam multiple times,

the multiple passes including a first set of passes and a second set of passes, the first reflector having a first alignment that is normal to the propagation direction of the first beam prior to reflection by the first reflector,

the first beam following a first nominal beam path when the first reflector has the first alignment,

the path of the first beam being sheared relative to the first nominal beam path during the first set of passes and during the second set of passes if the first reflector has an alignment other than the first alignment; and

redirecting the first beam after the first set of passes and before the second set of passes so that shear imparted during the second set of passes reduces or cancels shear imparted during the first set of passes.

35. The method of claim 34, further comprising directing the second beam along multiple passes through a portion of a second set of optics, the second set of optics including a third beam-splitting surface and a fourth beam-splitting surface that reflect the second beam multiple times,

the multiple passes through the second set of optics including a third set of passes and a fourth set of passes,

the second reflector having a second alignment that is normal to the propagation direction of a portion of the second beam that is reflected by the second reflector,

the path of the second beam being sheared during the third set of passes and during the fourth set of passes through the second set of optics if the second reflector has an alignment other than the second alignment; and

redirecting the second beam after the third set of passes and before the fourth set of passes so that shear imparted during the fourth set of passes reduces or cancels shear imparted during the third set of passes.

36. The method of claim 35, further comprising combining the first beam and the second beam into an overlapping pair of output beams after the first beam completes the first and second set of passes and the second beam completes the third and fourth set of passes.

37. A method comprising:

separating an input beam into a measurement beam and a reference beam;

directing the measurement beam to passes through a first beam-splitting surface;

reflecting the measurement beam in sequence by a measurement mirror, the first beam-splitting surface, a second beam-splitting surface, and the measurement mirror;

directing the measurement beam to pass through the second beam-splitting surface; and

combining the measurement beam with the reference beam to form an overlapping pair of output beams.

38. The method of claim 37, further comprising redirecting the measurement beam using a fold optic so that the measurement beam passes through the second beam-splitting surface a

second time, and is reflected in sequence by the measurement mirror, the second beam-splitting surface, the first beam-splitting surface, and the measurement mirror.

39. A method comprising:

directing a measurement beam along a measurement path that passes through a first set of optics and contacts a measurement mirror multiple times to produce a first intermediate beam, the measurement beam passing through a portion of the first set of optics multiple times;

directing a reference beam along a reference path that passes through a second set of optics and contacts a reference mirror multiple times to produce a second intermediate beam, the reference beam passing through a portion of the second set of optics multiple times; and

combining the first and second intermediate beams to form an overlapping pair of output beams, the first and second set of optics each having at least two reflecting surfaces and at least one beam-splitting surface positioned to reduce relative beam shear between the first and second intermediate beams caused by either the measurement mirror being at an angle relative to a first predefined position and/or the reference mirror being at an angle relative to a second predefined position.

40. The method of claim 39, further comprising directing the measurement beam to pass through a portion of the first set of optics in at least a first set of passes and a second set of passes, and

positioning the at least two reflecting surfaces and at least one beam-splitting surface of the first set of optics so that shear imparted to the measurement path during the first set of passes is compensated by shear imparted to the measurement path during the second set of passes when the measurement mirror is at an angle relative to the first predefined position.

41. A lithography system for use in fabricating integrated circuits on a wafer, the system comprising:

a stage for supporting the wafer;

an illumination system for imaging spatially patterned radiation onto the wafer;

a positioning system for adjusting the position of the stage relative to the imaged radiation; and

the apparatus of claim 1 for monitoring the position of the wafer relative to the imaged radiation.

42. A lithography system for use in fabricating integrated circuits on a wafer, the system comprising:

a stage for supporting the wafer; and

an illumination system including a radiation source, a mask, a positioning system, a lens assembly, and the interferometric apparatus of claim 1,

wherein during operation the source directs radiation through the mask to produce spatially patterned radiation, the positioning system adjusts the position of the mask relative to the radiation from the source, the lens assembly images the spatially patterned radiation onto the wafer, and the interferometric apparatus monitors the position of the mask relative to the radiation from the source.

43. A beam writing system for use in fabricating a lithography mask, the system comprising:

a source providing a write beam to pattern a substrate;

a stage supporting the substrate;

a beam directing assembly for delivering the write beam to the substrate;

a positioning system for positioning the stage and beam directing assembly relative one another; and

the apparatus of claim 1 for monitoring the position of the stage relative to the beam directing assembly.

44. A lithography method for use in fabricating integrated circuits on a wafer, the method comprising:

supporting the wafer on a moveable stage;

imaging spatially patterned radiation onto the wafer;

adjusting the position of the stage; and

monitoring the position of the stage using the method of claim 28.

45. A lithography method for use in the fabrication of integrated circuits comprising:

directing input radiation through a mask to produce spatially patterned radiation;

positioning the mask relative to the input radiation;

monitoring the position of the mask relative to the input radiation using the method of claim 28; and

imaging the spatially patterned radiation onto a wafer.

46. A lithography method for fabricating integrated circuits on a wafer comprising:

positioning a first component of a lithography system relative to a second component of a lithography system to expose the wafer to spatially patterned radiation; and

monitoring the position of the first component relative to the second component using the method of claim 28.

47. A method for fabricating integrated circuits, the method comprising the lithography method of claim 44.

48. A method for fabricating integrated circuits, the method comprising the lithography method of claim 45.

49. A method for fabricating integrated circuits, the method comprising the lithography method of claim 46.

50. A method for fabricating integrated circuits, the method comprising using the lithography apparatus of claim 41.

51. A method for fabricating integrated circuits, the method comprising using the lithography apparatus of claim 42.

52. A method for fabricating a lithography mask, the method comprising:

directing a write beam to a substrate to pattern the substrate;

positioning the substrate relative to the write beam; and

monitoring the position of the substrate relative to the write beam using the interferometry method of claim 28.